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BIDIRECTIONAL BIPOLAR STATIC INDUCTION DEVICE

"paragraph 0006". This result is achieved by disposing elements of the bipolar static induction transistors: [[two]] a gate, [[four]] sources and channels ~~and six electrodes~~ on either side of a lightly doped n-type silicon monocrystal substrate, and besides one ~~of said~~ channels channel of the multielemental structure is thicker than the other normally-off channels on either side of said substrate and said ~~thick channels are~~ channel is connected to the separate electrode on either side of said substrate.

"between paragraph 0006 and 0007". This result is achieved by a layer of a doped n+-type polysilicon is disposed on the silicon monocrystal surface.

This result is achieved by the control over both hole emission into and extraction out the lightly doped area are used as well as the current feedback for said control over emission into one.

This result is achieved by the thickness of said channels are small and the impurity concentration near said gates is high enough.

"paragraph 0007". This result is achieved by disposing an epitaxial ~~layers~~ layer of the same type of conductivity with the impurity concentration about 10.sup.17 cm.sup-3 on either side of said substrate; said gate, said sources and said channels are disposed in said epitaxil ~~layers~~ layer.

"between paragraph 0007 and 0008". This result is achieved by a layer of a doped n+-type polysilicon is disposed on the silicon monocrystal surface.

This result is achieved by said thick ~~channels are~~ channel is normally-on [[ones]] one.

"paragraph 0008. The offered transistors and transistor-thyristors can be applied for production, transfer and use of electric energy within a very broad range of power: from the control of electrical soldering to the control of most powerful turbogenerators and thermonuclear stations. They are effective for designing electronic transformers, power supply units, and "flexible transfers of alternating current". In the latter case ~~transistors~~ transistor-thyristors can be connected in series, which will allow to easily create high voltage system with operating voltage 10.sup.6 V and more with a control with light signals or by wireless. These transistors can be most widely used in the devices aimed at defending people from electric shock. They can also be used in systems with the unipolar power supply transmitting energy in both directions -- both from a source to a load (resonator) and from the load to the source. It will make it possible to

increase circuit efficiency with the voltage drop between a drain and source of the open transistor as a rule not exceeding 0.5 V and, if necessary, it can be highly close to zero.

"paragraph 0010". Though the structure of the transistor is symmetric the operating duty of the channel that is near the drain of the transistor essentially differs from the operating duty of the channel that is near its source. The electrical field reduces the concentration of holes in the former and increases their concentration in the latter. Owing to this, the hole concentration along an axis perpendicular to surface is trapezioidal in zero approximation. It puts certain restrictions both on the design parameters of BSIT and on designing of circuits in which these transistors are applied. Introduced in the structure the thick channel provides increasing of operating current (without latch). A threshold voltage of the thick channel is lower than that of the ordinary channel. Algorithm of control of the offered transistor under typical circumstances is more complicated than that of the transistor described above [3]. Let potentials of the gates are equal to potentials of the source and drain accordingly. The electrons flowing to the drain electrode can cause emission of the holes from the gate, disposed near the drain. The holes flow to the gate, disposed near the source. Part of the holes flow into the channel and causes the flow of the electrons to the drain. So, there is a positive feedback in the device. Device is latched. On-voltage of the latched device is more than on-voltage of the open transistor. To prevent the feedback it is necessary to provide so that electrons might flow to the drain free. It depends both on a control circuit and on the construction of the transistor. The part of the control circuit is represented on fig.10 of the application. Electrons might flow to the drain through open transistor 113 or 123. (In the simplest variant the thick channel drain electrode has been connected to the ordinary channel drain electrode with a conductor.) The construction of the transistor provides the way for electrons to the drain through the thick channel while transistor is closed or is being switched off. The potential of the thick channel drain electrode has to be positive or zero or little negative relative to the potential of the drain electrode of ordinary channel. The high drain voltage extracts electrons from the thick channel which is disposed near the source. The potential of the thick channel source electrode has to be positive so that the thick channel is closed. (It is allowed that the potential of the thick channel source electrode might equal zero, if the threshold voltages equal approximately 0.2 volt).

When changing polarity of the applied voltage, the source and drain change places, and the potentials of the thick channel electrodes should be changed accordingly so as the transistor is to remain closed. In this case the transistor can maintain voltages up to several kilovolt depending on parameters of the lightly doped area, in the first place from the thickness and number of donors between the gates as well as from an edge termination structure. To prevent an avalanche breakdown near the edge of the substrate, to decrease on-voltage, to increase speed of response and current density one might use a rib of rigidity of definite dimentions(fig.11). The channels of the transistor have to dispose in the recess bottom. In this case the avalanche breakdown can occur on the gate boundary near the edge of the recess bottom or near the edge of the thick channel depending on the parameters.

Another voltage on the gates is about 0.8 V relatively of the source and drain which are nearby. It provides the opening of the channels and hole emission into the channels and lightly doped area. The emission of holes to the lightly doped area is followed by electrons from the transistor source which makes the hole concentration and electron concentration practically the same in zero approximation and may reach the magnitude of 10.sup.17÷10.sup.18 cm.sup.-3 and more; resistance of the transistor drops abruptly due to conductivity modulation and the voltage between the drain and source of the transistor as a rule does not exceed 0.5 V at current density ≈ 1000 a cm.sup.-2(the thickness of the substrate is decreased by etching). There is a smoothly lowering voltage on the gate which is near the source of the transistor during the switching of the

transistor from on-condition to off-condition, owing to extraction. To decrease the loss of switching off the voltage on the gate which is near the drain of the transistor should be remain during the first part of time of switching off (approximately 1 us). It is permitted a small hole emission into lightly doped area during time of switting off.

"paragraph 0019". Inventions is explained with [[ten]] twelve drawings.

"between paragraph 0022 and paragraph 0023". Fig.9 represents bidirectional semiconductor device structure (prior art).

Fig.10 represents offered transistor with a part of the control circuit (one from several variants; for illustration only).

Fig.11 represents the substrate structure with the ribs of rigidity.

Fig.12 represents the offered transistor with a part of the high voltage control circuit (one of several variants; for illustration only).

Fig.13 represents a part of the circuit of the high voltage breaker with offered transistor-thyristors (one of several variants; for illustration only).

Fig.14 represents planar view of the offered transistor suitable for sequential connection. (Scale has not been kept. One of several variants; for illustration only).

Fig.15 represents planar view of the offered high current transistor. (Scale has not been kept. One of several variants; for illustration only).

"between paragraph 0025 and 0026". Bidirectional semiconductor device fig.9 comprises substrate 101, n+-type source 102, p-type base (anode) 103, p-type anode (base) 104, n+-type source 105, terminals 106,107.

Fig.10 comprises offered transistor 110, hole emission key 111, hole dischage (extraction) key 112, electron dischage key 113, amplifier with nonlinear feedback (polarity fixture)114,115,113; hole emission key 121, hole dischage (extraction) key 122, electron dischage key 123, amplifier with nonlinear feedback (polarity fixture) 124,125,123; (transistors 111,112,113,121,122,123 -- lowvoltage bipolar static induction transistors).

Fig.11 comprises the operation part of the substrate 131, ribs of rigidity 132, recess 133.

The ribs of rigidity increase a mechanical durability of the substrate and permit to decrease the thickness of the operation part and to improve the main performances of the transistor.

Fig.12 comprises the offered transistor 110, hole emission key 111, hole discharge (extraction) key 112, electron discharge key 113, amplifier with nonlinear feedback (polarity fixture)114,115,113; diodes 116-120, hole emission key 121, hole discharge (extraction) key 122, electron discharge key 123, amplifier with nonlinear feedback (polarity fixture) 124,125,123; diodes 126-130; (transistors 111,112,113,121,122,123 -- low-voltage bipolar static induction transistors).

If the drain voltage exceeds a threshold voltage it extracts electrons from the thick channel through the group of diodes 116-120 or 126-130 and prevents further increasing of the voltage on the ~~transistor~~ device. ~~In this case transistors~~ Seriesly connected transistor-thyristors ~~can be connected in series, which will~~ allow to easily create high voltage system with operating voltage 10.sup.6 V and more with a control with light signals or by wireless.

Fig.13 comprises button "start" 134, button "break" 135, former 136, solenoid 178, transformer 137, the offered transistor-hirystors 140,145; Schottky diodes 138,142,143,147, 148,160,162,174; diodes 150-159,164-173; resistors 139,141,144,147,149,161,163,175,176; switch 177, mobile contact 179, immobile contacts 180-183.

Resistors 139,141,144,147, 149,161,163,175 define boundaries of the latching.

Let the switch 177 be off. After the button "start" 134 is pushed, the former 136 switches on the solenoid 178 synchronously with alternating voltage. The mobile contact 179 is closed to contact 183 in several milliseconds and a small current flows to the contact 182 and the transistor-thirystors 140,145 through resistor 176. In several milliseconds the mobile contact 179 is closed to the contact 182 and the transistor-thirystors 145,140. The former 136 sends the pulse on the transformer 137 in one cycle of voltage the moment the voltage zero crossing is detected. The transistor-thirystors 140,145 are switched on and the current begins to flow through the contacts 180,179,182. In several milliseconds the contacts 179,181 are closed and the current flows to the load by the shortest way. Thus, the switching on takes place without arcing.

Let the alternating current flow to the load through the contacts 180,179 and 181. After the button "break" 135 is pushed the solenoid 178 disconnects the contacts 179,181 without synchronizing with voltage. The current flows between the contacts 180,179,182 and the transistor-thirystors 145,140 for several milliseconds. After the current zero crossing takes place the transistor-thirystors 140,145 (the lifetime of the holes has to be not very long) are switched off and the current is switched off. Thus, the switching off takes place without arcing within one cycle of voltage.

Planar view of the offered transistor fig.14 comprises source contact of ordinary channel 184, source contact of thick channel 185, gate electrode 186.

Dimentions of the different elements of the thick channel have been chosen taking into consideration an operation of the automatic control system of key (seriesly connected transistors) to remove possibility of an autogeneration.

Planar view of the offered transistor (maximum current order 10A) fig.15 comprises source contact of thick channel 187, area for gate electrode and source contacts of ordinary channels 188.

"after paragraph 0028". While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and the scope of the invention.

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Claims

1."canceled".

2."currently amended". A transistor comprising elements of bipolar static induction transistors: [[two]] a gate, [[four]] sources and channels ~~and six electrodes~~ on either side of a lightly doped n-type silicon monocrystal substrate;

one ~~of said~~ channel of the multielement structure is thicker than the other normally-off channels on either side of said substrate;

said ~~thick channels are~~ channel is connected to a separate electrode on either side of said substrate.

3."canceled".

4."currently amended". The transistor according to claim 2 wherein an epitaxial ~~layers~~ layer of the same type of conductivity with the impurity concentration of about 10.sup.17 cm.sup.-3 [[are]] is disposed on either side of said substrate;

said [[gates]] gate , said sources and said channels are disposed in said epitaxial ~~layers~~ layer.

5."previously presented". The transistor according to claim 2 wherein a layer of a doped n+-type polysilicon is disposed on the silicon monocrystal surface.

6."currently amended". The transistor according to claim 2 wherein the control over both hole emission into and extraction out the lightly doped area are used as well as the current feedback for said control over emission into one.

7."previously presented". The transistor according to claim 2 wherein the thickness of said channels are small and the impurity concentration near said gates is high enough.

8."previously presented". The transistor according to claim 4 wherein a layer of a doped n+-type polysilicon is disposed on the silicon monocrystal surface.

9."currently amended". The transistor according to claim 4 wherein said thick ~~channels are~~ channel is normally-on [[ones]] one.

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